

# Detectors for in-beam monitoring and imaging

Alejandro Mazal (Paris, France),

Denis Dauvergne (Lyon, France)

Katia Parodi (Munich, Germany),

Wolfgang Enghardt (Dresden, Germany)

Alberto del Guerra (Pisa, Italy)

**CERN**

**Medical Applications Workshop**

Divonne les Bains, 15th february 2014

## Menu of the day

1. Convenor's Introduction: big global scope

*A. Mazal (+ A. del Guerra)*

2. Rapporteur: specific subjects in depth

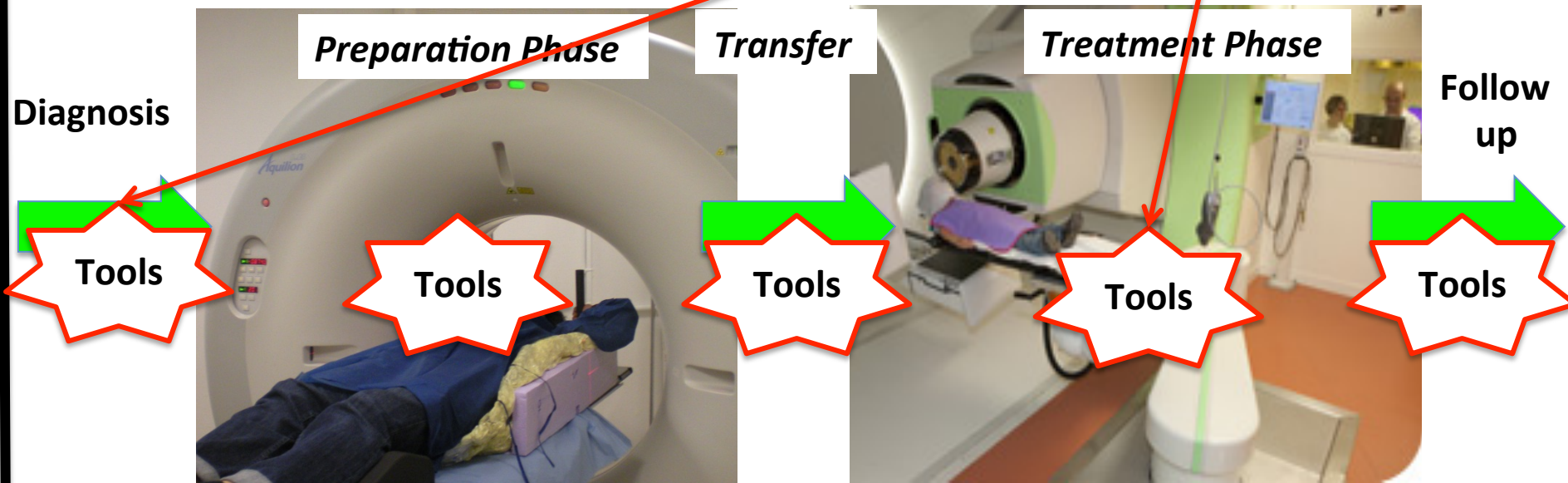
*D.Dauvergne (+ K.Parodi & W.Enghardt)*

3. Organisational proposals and discussion

*All of you !!*

# Detectors for in-beam monitoring and imaging. CERN Medical Applications Workshop

Patient based analysis (ex external radiation therapy)



"TIME"

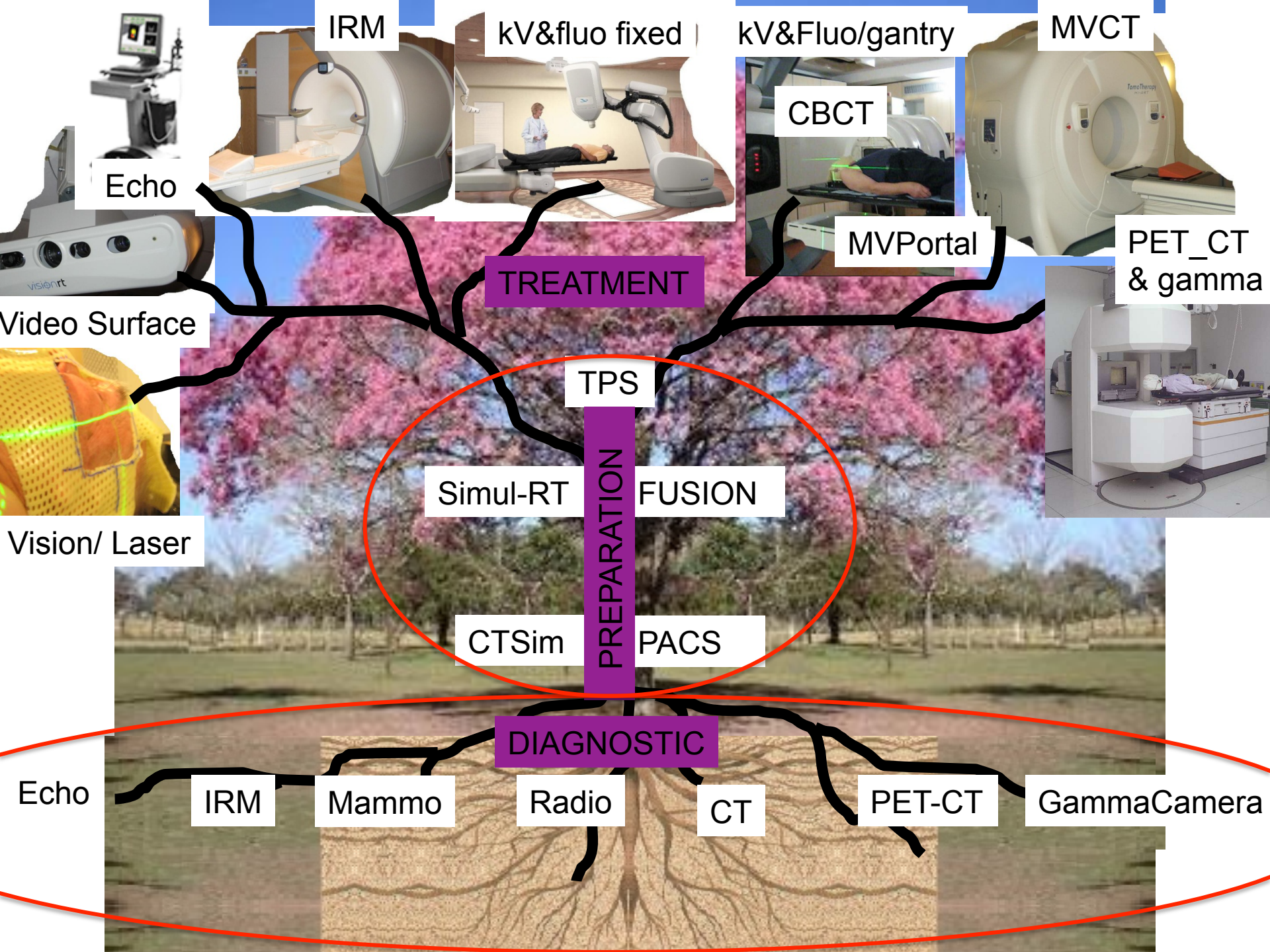
# IGRT : Image Guided Radiation Therapy



(The Tree of Imaging in Radiation Therapy)

*Lapacho (Tecoma curialis)*

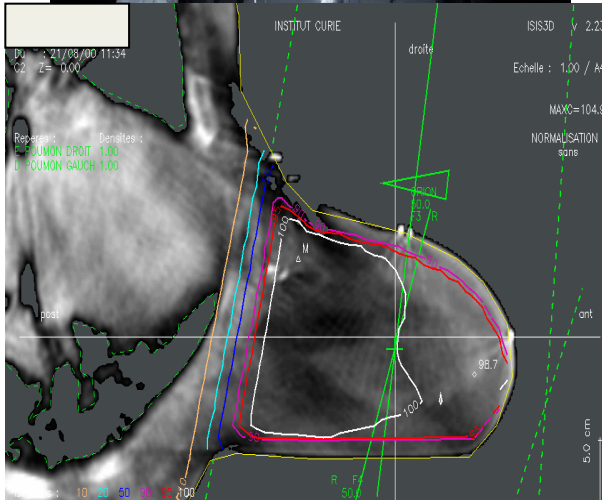






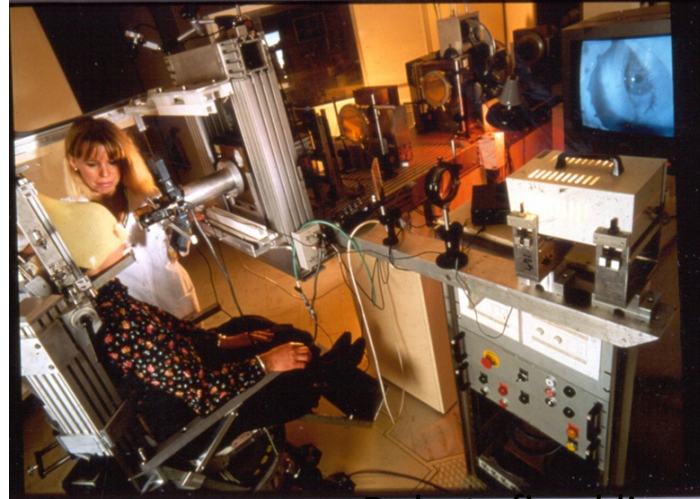
In spite of IGRT (previous slide)

In spite of patient positioning (see breast)

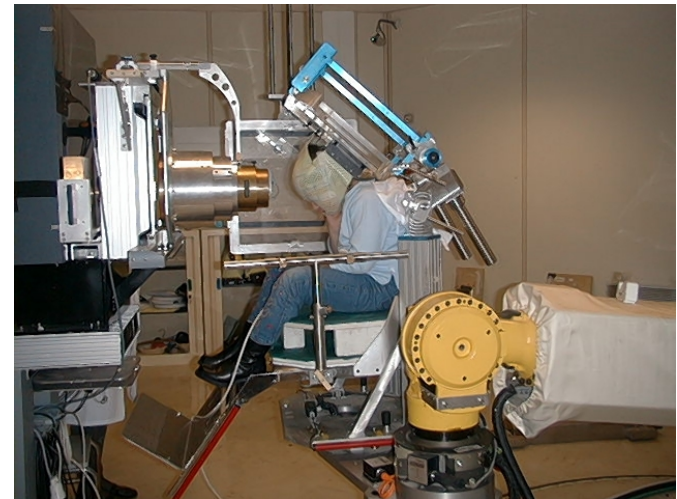


*Campana, Kirova et al, 2005*  
*Int J Radiat Oncol Biol Phys*

In spite of robots... ( see multiple robots)



Robots fixed lines Orsay

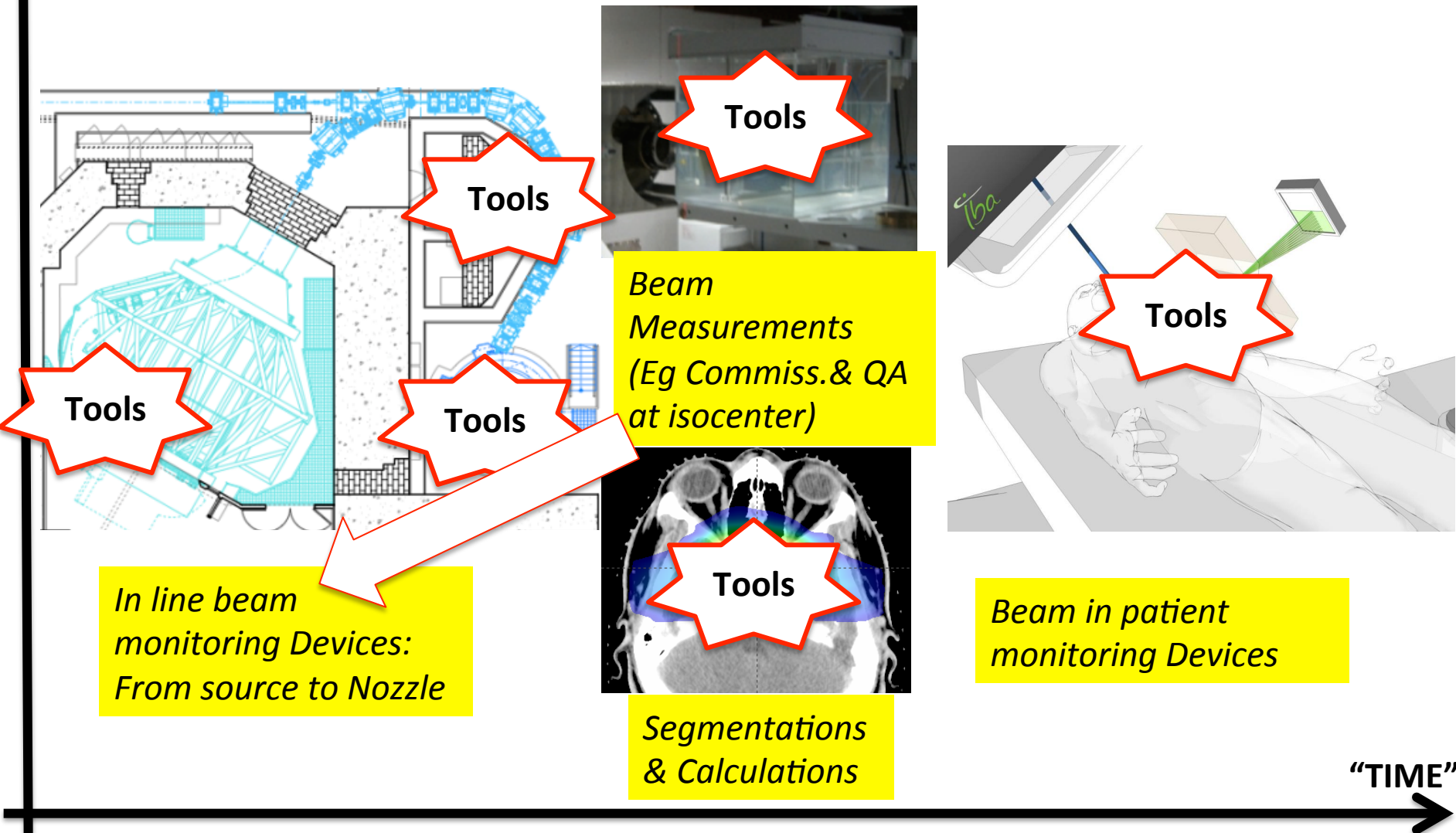


**“In clinical practice gantries and online detectors  
are and will be essential for the Q of treatment”**

# Detectors for in-beam monitoring and imaging.

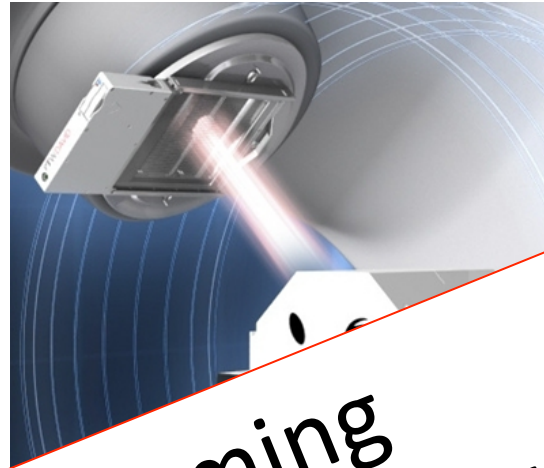
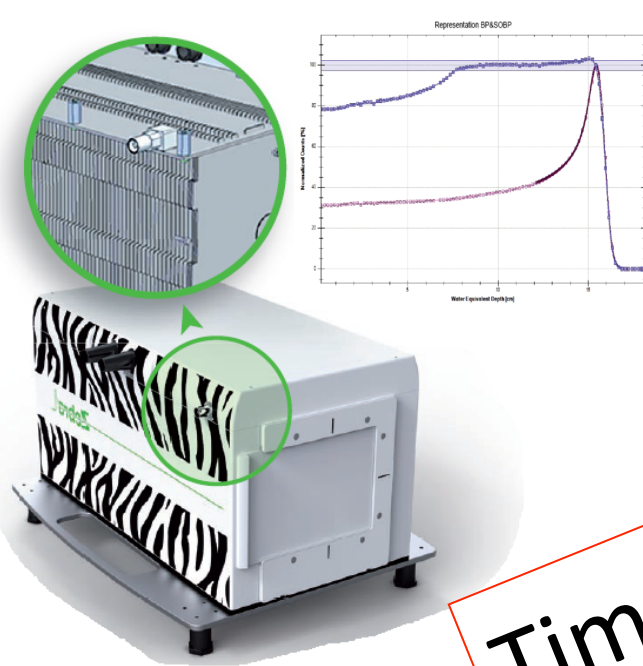
## CERN Medical Applications Workshop

Logistics & technological  
(ex external radiation therapy : hadrontherapy)



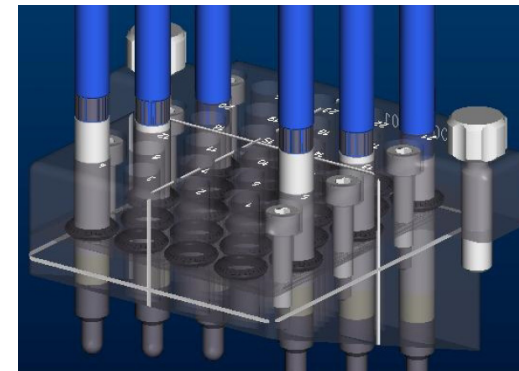
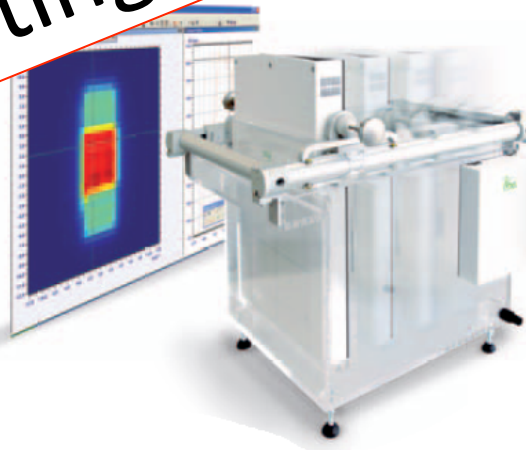
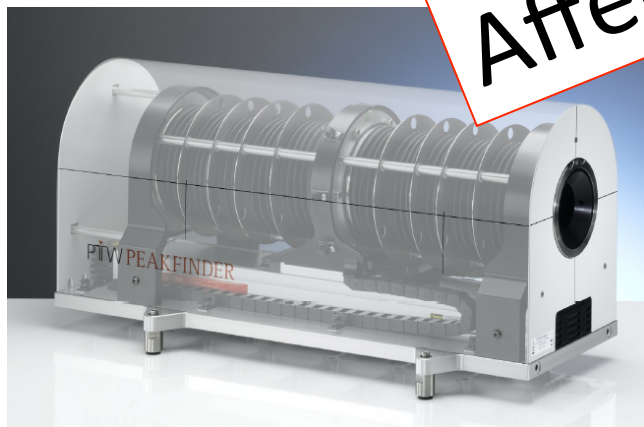


# Multidimensional Dosimetry Detectors for commissioning and Quality Assurance (Data from PTW and IBA dosimetry)



Time consuming  
Affecting throughput

Scintillators



1D/2D multilayer Ion Chambers

2D Arrays (chambers, semicond,...)  
in solid or water phantoms

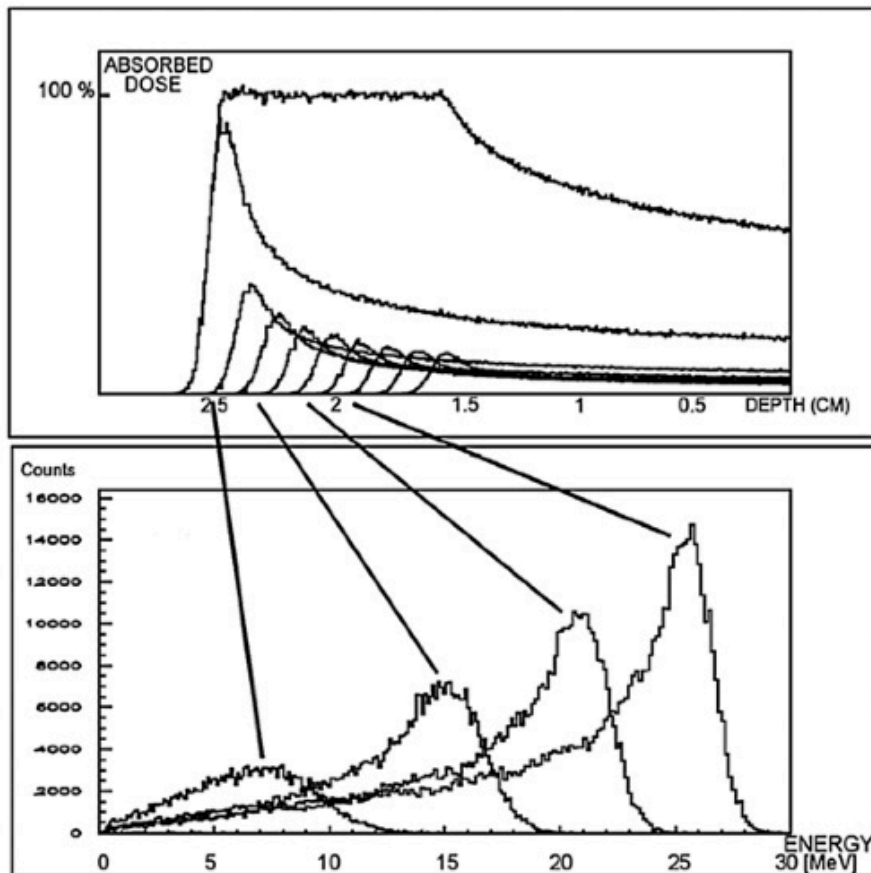


# Detectors for in-beam monitoring and imaging.

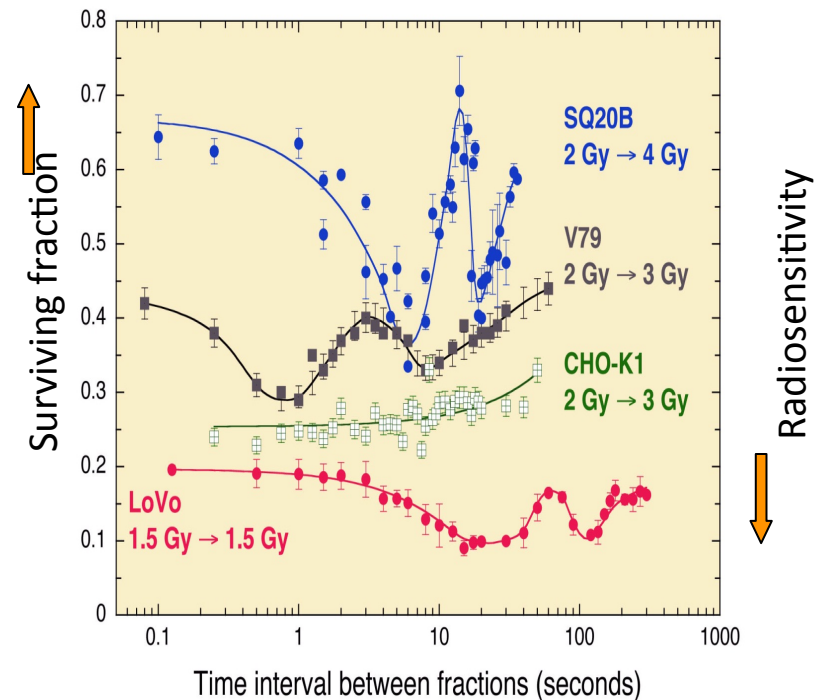
## CERN Medical Applications Workshop

### Research driven concepts (1): Physics and biology for medical apps

Different ions (Brahme et al)...  
or LET into a given beam (Pagannetti et al)



Split High Dose irradiation  
(Favaudon et al)

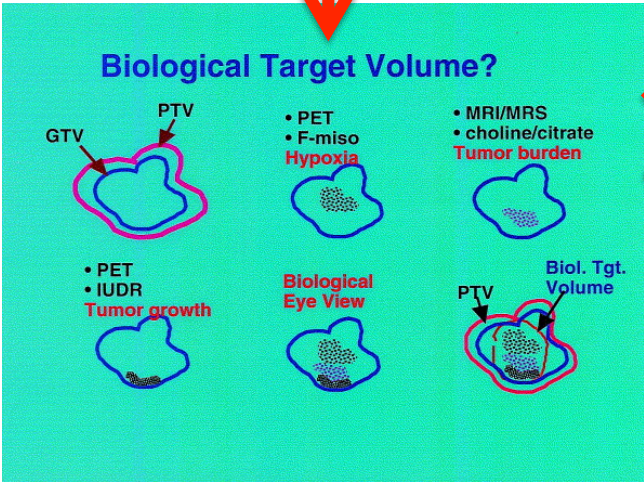
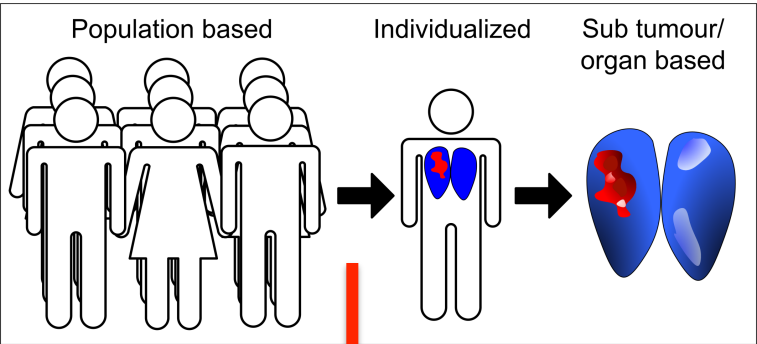


**Others :**  
**microstrips,**  
**nanoparticles,...**

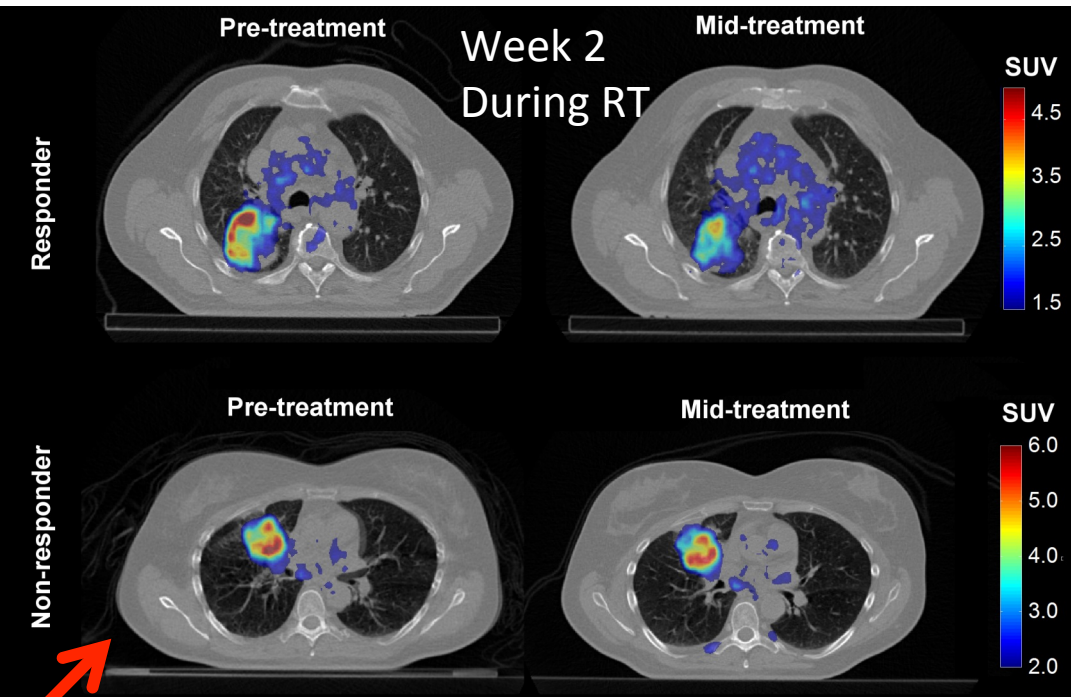


# PET Guided Radiotherapy

Philippe Lambin,  
Maastr, Belgium



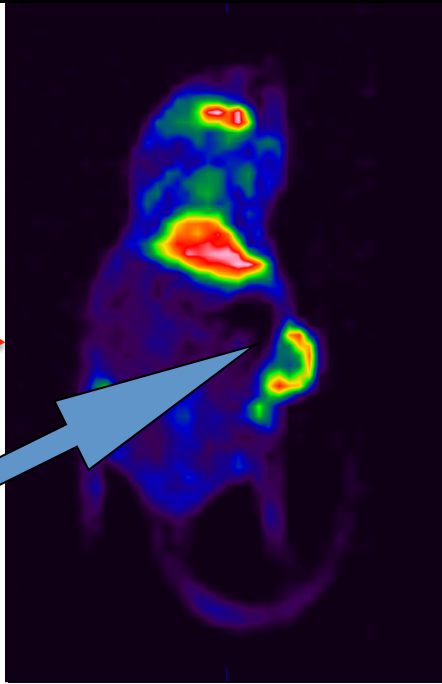
Ling et al



Van Elmpt et al

Drug Uptake  
 $^{89}\text{Zr}$  - Cetuximab

« Cold spot »:  
Less Drug Uptake  
( $\text{GTV}_{\text{LDU}}$ )

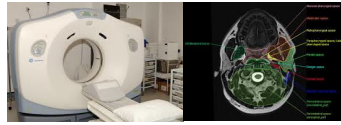


Aerts et al

**Dosimetry → Biometry**

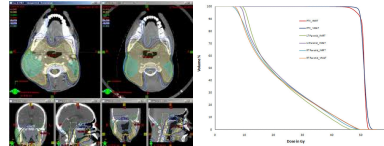
# The adaptive workflow (Tomo. Linacs)

Planning Imaging



Fract	Date	Time	Similarity	OutputM	Gamma	Com
1	20130826		Yellow	Yellow	Green	
2	20130827		Green	Yellow	Green	
3	20130828		Yellow	Green	Yellow	
4	20130829		Green	Green	Green	
5	20130830		Green	Yellow	Yellow	
6	20130902		Green	Green	Green	
7	20130903		Yellow	Red	Red	Intern
8	20130904		Green	Green	Green	
9	20130905		Green	Green	Green	
10	20130906		Yellow	Green	Green	
11	20130909		Green	Green	Green	
12	20130910		Green	Green	Green	
13	20130911		Green	Green	Green	
14	20130912		Green	Green	Green	
15	20130913		Yellow	Green	Green	
16	20130916		Green	Green	Green	
17	20130917		Yellow	Green	Green	
18	20130918		Green	Green	Green	
19	20130919		Green	Green	Green	
20	20130920		Green	Yellow	Green	
21	20130923		Green	Yellow	Red	Intern
22	20130924		Green	Red	Green	
23	20130925		Green	Green	Green	
24	20130926		Yellow	Green	Green	
25	20130927		Green	Green	Green	

Treatment Planning



Electronic Prescription



In room Imaging



Image Registration and patient setup



Treatment Delivery

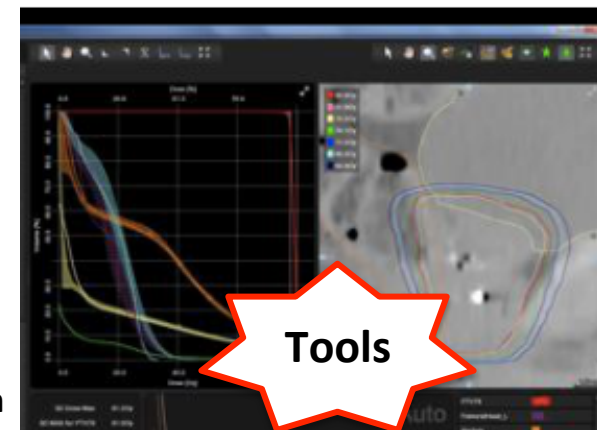
Adapt Treatment

Tools

Tools

Treatment Assessment

Coming (linacs): “Fast Knowledge Based Planning”



Varian

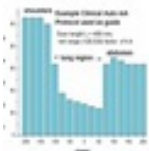




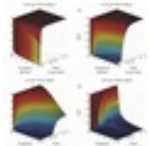
# Medical Physics

The International Journal of Medical Physics Research and Practice

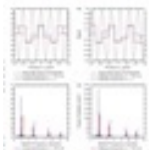
## EDITOR'S PICKS



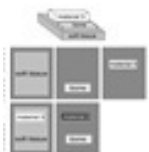
Dose equations for tube current modulation in CT scanning and the interpretation of the associated  $CTDI_{vol}$



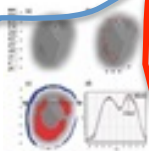
Oblique reconstructions in tomosynthesis. I. Linear systems theory



Oblique reconstructions in tomosynthesis. II. Super-resolution



Dimensionality and noise in energy selective x-ray imaging



Evaluating IMRT and VMAT dose accuracy: Practical examples of failure to detect systematic errors when applying a commonly used metric and action levels

## Imaging

## MOST READ THIS MONTH

Increasing dependence on industry-funded research creates higher risk of biased reporting in medical physics

Vision 20/20: Single photon counting x-ray detectors in medical imaging

The more important heavy charged particle radiotherapy of the future is more likely to be with heavy ions rather than protons

## MOST CITED THIS MONTH

Dosimetry of interstitial brachytherapy sources: Recommendations of the AAPM Radiation Therapy Committee Task Group No. 43

BEAM: A Monte Carlo code to simulate radiotherapy treatment units

A technique for the quantitative evaluation of dose distributions

## Research funding !

## Dosimetry

## Dose Evaluation





**Most read**

**Most cited**

**Latest articles**

**Featured articles**

**Review articles**

**In the last 30 days**

1. Optical properties of biological tissue
2. CT : Modelling Iterative reconstruction
3. MRI analysis for brain tumor studies
4. MRI Tracer kinetic modelling
5. X-ray phase-contrast imaging

**"Imaging"**

6. Brachytherapy : Monte Carlo calculated doses for permanent implant in lung
7. Out-of-field dose in photon craniospinal irradiation
8. Dosimetry: when  $^{60}\text{Co}$  is the reference quality for charged-particle and photon beams

**"Dosimetry"**

9. Automatic 3D ultrasound calibration in IGRT
10. Automated segmentation of pulmonary structures in CT

**Automatic tools**

# Detectors for in-beam monitoring and imaging. CERN Medical Applications **Workshop**

People =>  
Human & Organizational factors



"TIME"

# **Global scope “Detectors for in beam monitoring and imaging”**

**In beam : from source to patient**

**Imaging : from diagnosis to follow up**

**And all also for basic research (eg in physics, technology and biology)**

## **Synthesis from Alberto del Guerra’s Memo for this meeting**

### **Need a facility to test :**

Proof of principle, pre-engineered hardware, software and simulation systems for detectors and imaging reconstruction, segmentation, classification, to be used in radiation therapy, in ionizing radiation imaging, preclinical applications, and more.

### **Fields of application :**

From proton therapy to radioactive beams,

Novel PET technology, New and Hybrid Imaging (e.g., Photoacoustic, Cerenkov,..)

Sub-10 ps electronics , Data acquisition systems, , Computing networks

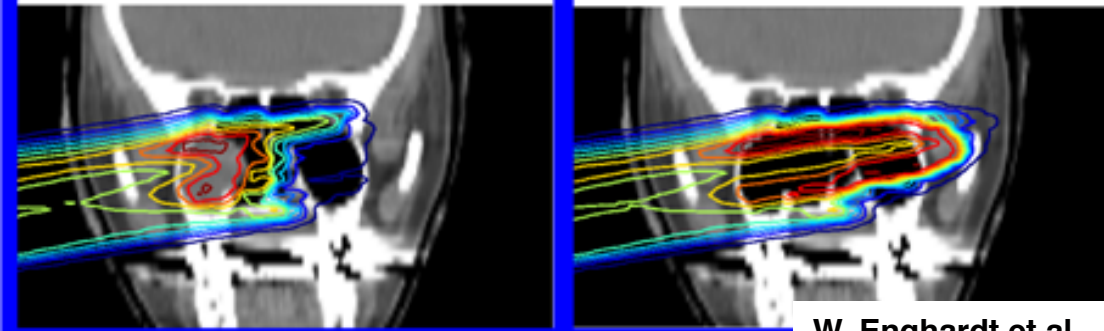
Very fast detectors for synchrotron radiation biological applications...

## Two “black” practical problems in hadrontherapy :

Anatomical changes  
and all uncertainties in dose deposition

Originally planned  
dose distribution

Dose recalculation  
on modified CT



W. Enghardt et al.

Patient activation & PET  
Gamma prompt  
Proton Radiography  
Others

**Next:**

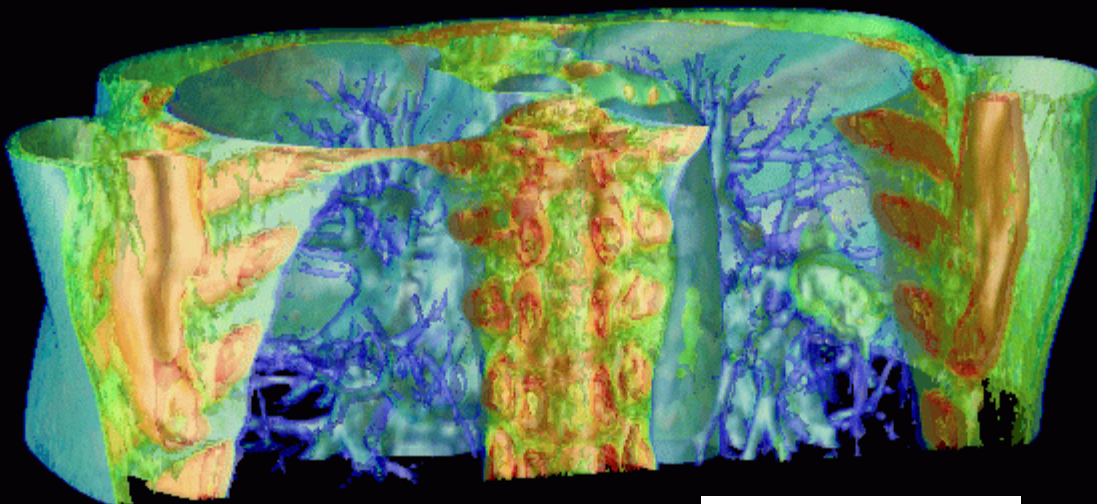
**Denis Dauvergne**

Katia Parodi

Wolfgang Enghardt

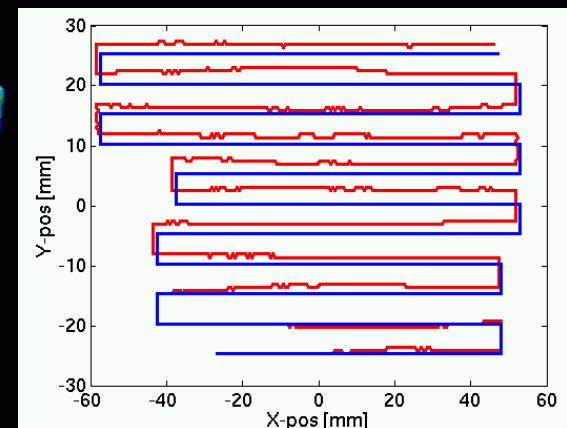
(Joao Seco)

Organ movements and mitigation approaches



E.Rietzel et al.

...with scanned beams (interplay)



Ch.Bert, G. Baroni , T.Furukawa  
& others in the room...



Denis ...



A few global questions :

- Not 10-30 years scope, probably shorter ?
- Link with Industry ?
- “Clinical adaptive online treatment of the day” could drive developments in the area of detectors for in beam monitoring and imaging?

( and specific questions from Denis’ talk...)